Domain Modeling with Integrated Ontologies: Principles for Reconciliation and Reuse

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Background. We discuss the problems of reuse and commitment in our work on the domain ontology for EON, an architecture for integrating distributed problem-solving components for management of guideline-directed medical therapy[i]. The problem-solving components that make up the EON architecture include a therapy-planning component that takes as input a clinical protocol description and patient data and generates a situation-specific therapeutic plan. Another component, called RÉSUMÉ, does the temporal abstraction and reasoning. Each of the components had its own method and domain-specific application ontology. A central problem in the EON project was how to create a global ontology that could be reused as an integrated and independently maintained ontology for the entire EON system.

Methods. From our experience in constructing the EON domain ontology, we have developed three principles which elucidate elements of a domain-modeling process which shares and reuses ontologies maximally across different tasks. The first principle is that it is advantageous to constrain the design process such that a controlled medical vocabulary is used to populate the elements of the common domain ontology. Next, we present a strategy to deal with the *interaction problem*, a name given to the domain-modeling problem to reflect the conflicts in the use of ontologies prepared for different tasks. The second principle is that we can most efficiently address the interaction problem by adding frame-based attributes rather than mappings between vocabulary elements in each ontology. Third, we use a principle of maximum modularity in the design of the central domain ontology by using multiple-parent hierarchies with subsumed domain- and task-specific ontologies.

Results. We learned that reconciling conflicts in domain had to arise out of a coherent view of the syntactic, semantic, and structural integration of the component ontologies. Syntactic integration required us to use a controlled medical vocabulary throughout the system. This vocabulary ensured that the commitment of each task to a named concept was internally consistent. Moreover, it allowed for the potential use of a larger standardized lexicon, such as SNOMED, which could ensure external consistency with a wider set of applications. Semantic integration also required us to consider ontological commitment and reuse. We found that the interaction problem could be addressed if we were willing to increase the complexity of the classes of the component ontologies in our framed-based system by extending their frames to include reconciling information rather than by mapping between conflicting classes. In essence, we showed that we can simplify domain modeling even if the amount of knowledge acquisition based on the domain model cannot be reduced. Moreover, we can reduce the complexity of the class hierarchy in the domain model by increasing the number of the specific instances of those classes in the knowledge base. Finally, we showed that we could add to the structural integrity and reusability of the domain model by increasing the modularity of the global ontology using multiple parenting and subsumed ontologies.

Conclusions. There is now a great chasm between the availability of numerous reusable problem-solving methods and relative paucity of good reusable medical domain ontologies. Since the development of reusable domain ontologies is now the most costly and rate-limiting step in the construction of working knowledge-based systems, the problem of reconciliation and reusability of disparate ontologies has become more acute. We have identified design principles that allow us to solve the problem of integrating inconsistently committed subsets of a global domain ontology so that the goal of reuse can be achieved.

[i] Musen MA, Tu SW, Das AK, Shahar Y. EON: A component-based approach to automation of protocol-directed therapy. *JAMIA* 1996; 3:367-388.

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